CH2M HILL
Engineers
Planners
Economists
Scientists

May 26, 1993

WDC35168.A2.60

Mr. Richard S. Weber, Director
Department of Environmental Resources
County of Loudoun
750 Miller Drive, S.E.
Leesburg, Virginia 22075

Dear Mr. Weber:

Subject: The Woods Road Solid Waste Management Facility

CH2M HILL has prepared the attached supplemental information, as requested by the County of Loudoun (the County), to support the Woods Road Solid Waste Management Facility Part A Permit Application (Application) submitted to the Department of Environmental Quality (DEQ) on February 19, 1993 The purpose of this supplemental information is to address the March 14, 1993 DEQ permit review comments. Responses to each of the ten DEQ comments are addressed below as follows:

1. The inactive domestic water supply wells around and within the proposed facility limits were not used to gather water level readings. At the time of the site investigation and preparation of the Part A permit application, the exact construction, vertical elevation, and casing stick-up of each of these wells was not known, nor was the hydrogeology at the site defined. The subsurface investigation conducted as part of the Part A permit application provided sufficient information to define the uppermost groundwater aquifer and groundwater levels within the facility limits (see Figures 8-15 through 8-19).

   Based upon the results of the site investigation, it has been determined that there is only one aquifer beneath the site, and regardless of their construction, the domestic water supply wells could provide supplemental groundwater level information. However, the County has recently surveyed these wells in preparation for abandonment prior to construction.

   Figure 8-14 provides information on eleven site domestic wells from which well yield was compared to depth. The requested information from these wells is presented in the following table.

Site Domestic Water Supply Wells		
Well	Depth (FT)	Yield (GPM)
DW1	126	20
DW11	150	30
DW12	125	40
DW17	160	15
DW22	265	6
DW23	225	30
DW31	245	10
DW40	290	5
DW48	100	20
DW49	100	20
Abandoned well near DW12	300	0

2. We agree with the DEQ that the criterion stipulated in Section 5.1.A.1 of the regulations is not applicable since the Woods Road Facility will be more than 10,000 feet from the ends of the runway at the Leesburg Municipal Airport. The Airport safety issue was addressed to the extent presented in the Part A application in response to prior concerns raised by the FAA in written correspondence to the County, dated June 28, 1990 and September 11, 1990. Copies of these documents are contained in the attachment to Appendix A, Airport Safety and are a matter of public record. The FAA was brought into the County's landfill site selection process in 1989 by an affected property owner who also was an official with the Air Line Pilots Association and owned a corporate jet aircraft based at the Leesburg Municipal Airport.

The County has subsequently completed ornithological studies at the existing county landfill which clearly demonstrate to the FAA a finding that development of the Woods Road solid waste management facility will not impact operations of the Leesburg Municipal Airport (e.g., no increase risk of bird strikes to aircraft approaching or departing the airport). The County has also demonstrated its willingness to cooperate with the FAA by committing to the 12 bird mitigation measures contained in the Joint Resolution adopted on February 3, 1993 by the Board of County Supervisors and the Mayor and Council of the Town of Leesburg as a condition of its permit with the DEQ. The joint resolution is contained in Appendix A of the Part A application.

The County's objective in presenting this material was to correct the record with regard to the previous FAA correspondence and to bring this matter to a close prior to the DEQ landfill permit application hearing. A copy of the materials contained in the Part A permit application submittal were provided to the FAA on January 31, 1993. The FAA recently reviewed these materials and advised the County that they no longer object to development of the Woods Road Facility. A copy of their letter is attached.

3. We have reviewed our seismic risk analysis for the Woods Road site and determined that the 50-year return period stated in the Part A permit application was the result of a typographical error. The correct figure should have been 250 years. The maximum horizontal acceleration of bedrock expected in the vicinity of the site from an earthquake with a 250-year return period is 0.1g (g equals gravitational acceleration).

4. The Woods Road site (see Section 6.0 of the Part A Permit Application) is a consolidation of several properties which the County of Loudoun currently owns or has a real-estate lease-purchase agreement on. Certification of ownership of the site by Loudoun County was provide under separate cover, dated May 24, 1993. This information is incomplete and should be replaced with the attached information.

5. During 1989 through 1990, Loudoun County conducted a siting study to identify an area for development of a new sanitary landfill to provide the County with undisrupted waste disposal capacity once their current landfill reaches capacity. The siting study consisted of screening the entire 522 square mile county in search of a minimum of 200 acre parcel. The screening process was based on 24 technical criteria which included exclusion of all land within 100-year flood plains and exclusion of a zone 100 feet from each side of all perennial streams. These criteria included the vast majority of wetlands.

   In general, Loudoun County topography is highly dissected with streams and drainageways. During the siting study, it was not possible to address minor wetlands along intermittent drainageways or upland areas since site specific field investigations would be required to identify these minor wetland areas. The Woods Road site is located near a local topographic high where the density and size of drainageways are diminished.

The Woods Road site was selected based on this screening process (see attached summary and technical criteria) and the fact that no practical alternative existed to avoid placing the landfill facility in some minor wetland areas.

The proposed Woods Road Solid Waste Management Facility limits were planned with an eye towards minimizing impacts on wetlands, to the extent practical. A small, narrow wetland exists within the facility limits. Avoiding this wetland would have resulted in a significant reduction in usable airspace for waste and would have increased the cost of developing the landfill.

Construction and operation of the proposed facility will not violate applicable water quality standards and erosion and sedimentation control provisions because the County intends to adhere to all federal, state, and local regulations. The proposed facility will be designed to meet and conform with these standards and regulations.

A wetland delineation was conducted at the Woods Road site. The U.S. Army Corps of Engineers (COE) has visited the site and concurs with the delineation (see attached COE correspondence). The proposed facility will affect approximately 1.5 acres of jurisdictional wetlands. The COE has indicated and agreed that filling of these wetlands is permitted under Section 404 of the Clean Water's Act. Loudoun County is currently preparing a mitigation plan associated with application for Nation Wide Permit No. 26.

6. The minor flood plain indicated in the Part A permit application is defined by Loudoun County zoning regulations as the limits of the 100 year flood for a minimum watershed area of 100 acres. The 100 acre historical watershed limit is shown in Figure 1 along with the approximate limits of the disposal area for the proposed Woods Roads Solid Waste Management Facility. The extent of the flood plain shown in the Part A permit application will be reduced as a result of 1993 improvements to the existing landfill which impact the watershed area. These include construction, which is currently underway, of a runon control channel and expansion of an existing stormwater management pond, SB-1. This will cause a diversion of watershed drainage and a corresponding reduction of the watershed area which defines the limit of the Loudoun County 100 year

minor flood plain.

The 100 acre revised watershed limit (following the current construction) is shown on Figure 1. The revised limits of the minor flood plain and its separation relative to the approximate limits of disposal (or edge of waste) are depicted.

The procedure used to determine these revisions consists of two steps. First, the area diverted from the watershed due to construction improvements was measured, then a trial and error method was used to pick new watershed outlet points and measure the watershed area until a total of 100 acres resulted. This point was then selected as the upstream limit of the revised 100 year minor flood plain.

The Part B permit application for the proposed Woods Road Solid Waste Management Facility will include specific provisions to control drainage and provide stormwater management. These features are expected to further reduce the extent of the minor flood plain. The proposed facility limits will not restrict the flow of the flood plain nor result in the washout of solid wastes.

7. Information gathered as part of the subsurface investigation conducted at the site provides suitable hydrogeological information to demonstrate our knowledge and understanding of the hydrogeology at the site. No other wells at the Woods Road facility are currently suitable for conducting a continuous drawdown pumping test similar to that conducted at DW20.

8. Groundwater level measurements are continuing to be taken on a regular basis. Table 8-4 (attached), from the Part A permit application has been updated to reflect measurements taken in February, March and April 1993.

9. CH2M HILL contacted and collected information from agencies in supporting the claim that no threatened or endangered species, unique natural areas, or historic areas exist at the proposed landfill site. Copies of these correspondences are provided as supplemental information. Also attached is a copy of the letter summary, prepared by R. Christopher Goodwin & Associates, Inc., which presents the *Results of Preliminary Historical, Archeological, and Architectural Assessment for the Proposed Expansion of the Loudoun County Landfill.*

10. The County proposes to monitor the uppermost groundwater aquifer below the site of the Woods Road solid waste management facility utilizing the following approach:

1. Existing background groundwater monitoring wells MW-13 and MW-21, which are the current upgradient wells for the existing County Landfill, could continue to be utilized as permanent background wells for both sites since they are upgradient of both. The sampling interval used for the existing landfill monitoring program will be continued because a four-quarter statistical baseline already has been established for these wells.

2. The "footprint" of the disposal area for the Woods Road facility will be physically separated a distance of 400 to 500 feet downgradient from the edge of waste of the existing County Landfill.

3. The monitoring network will be upgraded with the startup of each of the four disposal areas. A four-stage monitoring plan will be described in the Part B permit application.

4. Three or more groundwater monitoring wells will be utilized to sample the groundwater between the then closed County Landfill and the Woods Road facility. It is anticipated that three upgradient wells in this area will be sampled during the operation of the initial northeast cell and that a total of four upgradient wells will be sampled during all later phases of operation. These wells will serve as downgradient wells for the then closed County Landfill and as upgradient wells for the Woods Road facility. It is anticipated that two existing groundwater monitoring wells will be used for this purpose (L4A and MW-35). At least one upgradient groundwater well will be located within each of the three groundwater sub-basins that discharge from the existing County Landfill site into the site of the Woods Road facility.

5. The design life of the Woods Road facility is expected to be about 40 years. The facility will consist of a single 135-acre area fill that will be composed of four connected lined cells, each with its own leachate collection system, leachate sump, and underlying leak detection system. The performance of the liner system in each cell will be monitored independently of the groundwater monitoring system. The leak detection system will serve as an early warning mechanism and will allow time for additional downgradient monitoring wells to be installed adjacent to the cell, if warranted.

6. The four cells will be constructed sequentially, starting in the northeast quadrant of the Woods Road facility and proceeding counterclockwise to the northwest, southwest, and southeast. The first lined disposal cell,

which will be about 40 acres in size, will be physically located no closer than 600 feet from the existing County Landfill, and approximately 400 feet further downgradient of existing monitoring well MW-18, in which VOCs have been detected. Since the first cell will be operated for a period of about 10 years, the County will have sufficient time and physical space to continue to monitor the advancement of any groundwater contaminants from the original unlined fill area, or to implement a remediation program if warranted, prior to construction of the second cell. The footprint of the second cell of the Woods Road facility will be located no closer than 150 feet downgradient of MW-18.

7. Sampling data from the December 1992 sampling event indicate that volatile contamination in groundwater upgradient of the Woods Road Facility is limited to an area near MW-18 and MW-12 and has not advanced to other wells farther downgradient (L4A and MW-35) that are located between the existing County landfill and the proposed "footprint" of the disposal area for the Woods Road facility. In addition, a comparison to previous sampling rounds indicates the concentrations of volatile organics is not increasing with time. These findings indicate that the VOC "plume" is relatively stable and is not migrating rapidly downgradient.

   The County intends to prevent the contaminants detected in monitoring wells MW-12 and MW-18 from ever reaching the footprint of the Woods Road facility through the implementation of a corrective action plan prior to the start of operations at the Woods Road facility. Based on the attached schedule, the County will submit an assessment of corrective measures to the DEQ in May 1994. On this basis, groundwater flowing below the Woods Road facility disposal cells will not contain leachate from the then closed County landfill that could impede detection of a future release of contaminants from the Woods Road facility.

8. A number of permanent downgradient monitoring wells will be installed on the east, south, and west sides of the facility where the three groundwater sub-basins discharge in an offsite direction from below the perimeter of the waste disposal cells. The exact number and location of the wells will be described in the Part B permit application. Several "temporary" groundwater monitoring wells will also be located immediately downgradient of the first disposal cell (within the interior of the facility) to measure the quality of the groundwater as it discharges from below this cell. These "temporary" monitoring wells will be properly

abandoned when the subsequent cells are installed, as specified in the monitoring implementation plan to be submitted in the Part B permit application. The "temporary" monitoring wells, two of which currently exist, will be in service for approximately 10 to 30 years and will allow a comparison of groundwater quality to be made upgradient and downgradient of the earlier cells for that period of time.

We are of the opinion that this strategy will be satisfactory to monitor groundwater quality at the Woods Road facility, and to differentiate between the performance of the then closed County Landfill and the Woods Road facility. There will be ample space between the two landfills to implement a pump and treat corrective action plan for the closed landfill, should it be warranted. The use of multiple upgradient monitoring wells from the Woods Road facility will allow background wells to be maintained outside the zone of influence of any pump and treat system.

Please do not hesitate to give me a call if you have any questions.

Sincerely,

CH2M HILL

Martin A. Reif, P.E.
Task Manager

Attachments
parta\cr052693

cc Sharon Hodges

Table 8-4
GROUNDWATER ELEVATIONS IN MONITORING WELLS

				September 23, 1992		November 4, 1992		December 9, 1992		December 28, 1992		February 8, 1993		March 30, 1993		April 26, 1993	
Monitoring Well	Hydrogeologic Unit Well Screened In	Approximate Ground Surface Elevation (ft NGVD)	Elevation of Top of PVC Well Casing[a] (ft NGVD)	Depth to Water (ft)	Groundwater Elevation (ft NGVD)	Depth to Water (ft)	Groundwater Elevation (ft NGVD)	Depth to Water (ft)	Groundwater Elevation (ft MSL)	Depth to Water (ft)	Groundwater Elevation (ft MSL)	Depth to Water (ft)	Groundwater Elevation (ft MSL)	Depth to Water (ft)	Groundwater Elevation (ft MSL)	Depth to Water (ft)	Groundwater Elevation (ft MSL)
L1	Saprolite	468	471.34	132.57	338.77	132.64	338.70	132.90	338.44	132.86	338.48	132.72	338.62	132.35	338.99	131.99	339.35
L1D	Saprolite	469	472.14	133.23	338.91	133.30	338.84	133.52	338.62	133.45	338.69	133.32	338.82	132.90	339.24	132.44	339.70
L2	Interface/Bedrock	448	451.30	117.65	333.65	117.64	333.66	117.54	333.76	117.14	334.16	116.44	334.86	115.04	336.26	113.55	337.75
L3	Saprolite/Perched	408	411.26	29.30	381.96	29.92	381.34	29.85	381.41	27.20	384.06	24.23	387.03	19.92	391.34	17.41	393.85
L4A	Saprolite	395	397.74	61.54	336.20	61.63	336.11	61.56	336.18	61.21	336.53	60.31	337.43	NM	NM	57.90	339.84
L4D	Bedrock	394	396.77	60.65	336.12	60.73	336.04	60.64	336.13	60.31	336.46	59.44	337.33	NM	NM	56.13	340.64
L5	Saprolite	388	391.26	52.40	338.86	52.58	338.68	51.90	339.36	51.95	339.31	55.10	336.16	47.33	343.93	NM	391.26
L6	Saprolite	403	406.21	74.33	331.88	74.45	331.76	74.15	332.06	73.57	332.64	72.62	333.59	70.57	335.64	68.78	337.43
L7	Saprolite/Interface	392	394.78	62.81	331.97	62.95	331.83	62.56	332.22	61.99	332.79	61.02	333.76	58.87	335.91	57.11	337.67
L7D	Bedrock	392	394.64	62.66	331.98	62.81	331.83	62.45	332.19	61.85	332.79	60.88	333.76	58.72	335.92	56.96	337.68
L8	Saprolite/Interface	433	436.16	108.82	327.34	108.88	327.28	108.62	327.54	108.11	328.05	107.00	329.16	105.41	330.75	103.54	332.62
L9	Saprolite/Perched	397	400.18	42.86	357.32	42.80	357.38	42.06	358.12	40.74	359.44	35.71	364.47	31.10	369.08	28.53	371.65
L10	Saprolite	379	382.25	50.34	331.91	50.42	331.83	50.10	332.15	49.50	332.75	48.54	333.71	46.52	335.73	44.78	337.47
L11	Interface/Bedrock	362	364.97	33.22	331.75	33.35	331.62	33.05	331.92	32.45	332.52	31.52	333.45	29.46	335.51	27.67	337.30
L11D	Bedrock	363	365.75	34.11	331.64	34.27	331.48	33.96	331.79	33.40	332.35	32.46	333.29	30.39	335.36	28.63	337.12
L12	Saprolite	358	360.51	20.90	339.61	21.48	339.03	19.86	340.65	17.56	342.95	17.16	343.35	10.39	350.12	11.58	348.93
L13	Saprolite	356	359.08	25.92	333.16	25.72	333.36	24.14	334.94	20.26	338.82	17.34	341.74	6.84	352.24	10.24	348.84
L14	Saprolite	357	359.69	31.72	327.97	31.45	328.24	30.35	329.34	28.58	331.11	26.72	332.97	21.40	338.29	21.29	338.40
L15P1	Bedrock	425	427.88	101.16	326.72	100.10	327.78	99.74	328.14	99.22	328.66	98.32	329.56	97.15	330.73	95.77	332.11
L15P2	Bedrock	425	427.88	94.35	333.53	94.29	333.59	94.30	333.58	94.32	333.56	94.31	333.57	94.29	333.59	94.20	333.68
L16	Saprolite	391	393.71	56.34	337.37	56.60	337.11	57.02	336.69	56.42	337.29	54.08	339.63	49.65	344.06	47.42	346.29
L17	Saprolite	373	376.03	42.32	333.71	42.20	333.83	41.60	334.43	40.54	335.49	37.97	338.06	34.33	341.70	30.28	345.75

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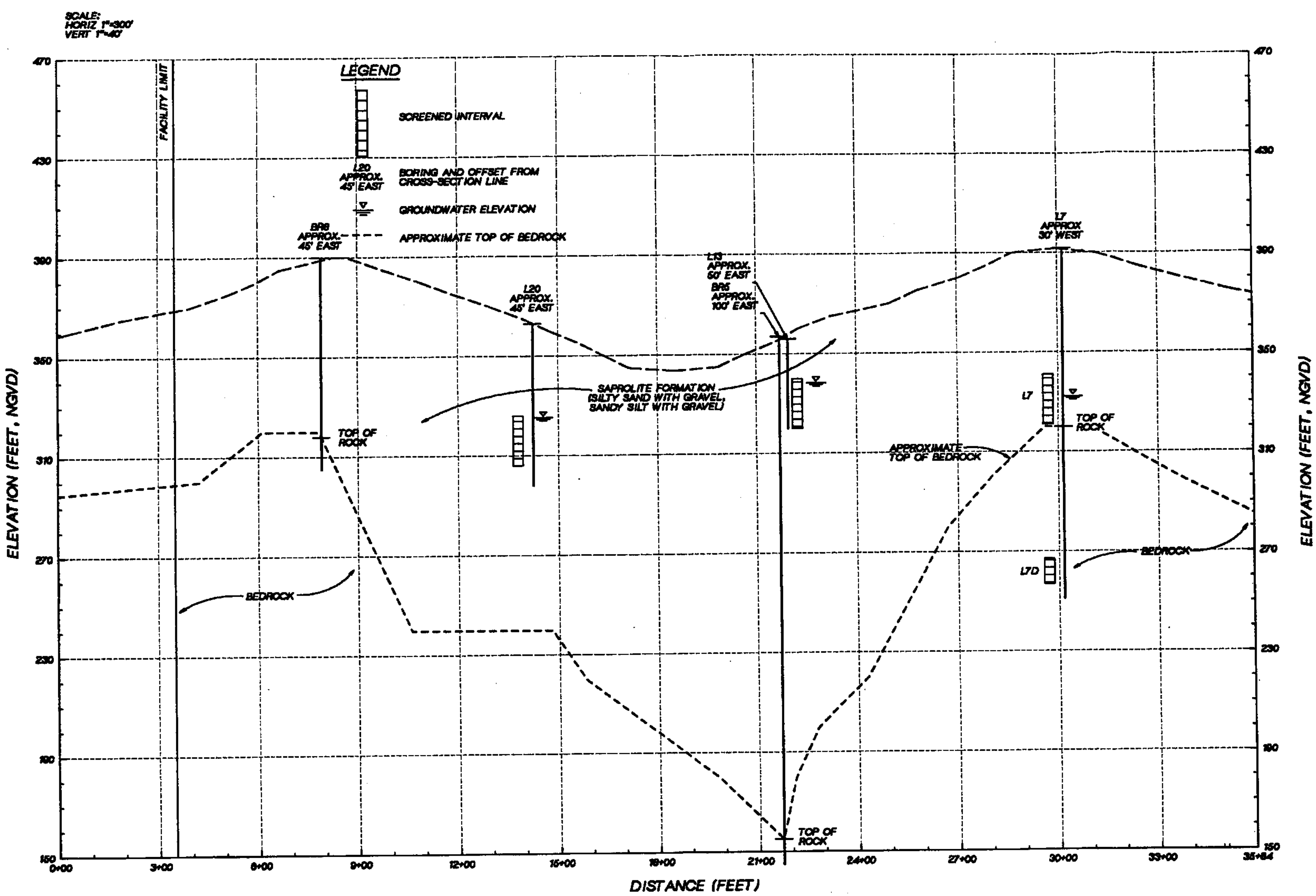
L18	Interface	389	392.38	65.95	326.43	66.05	326.33	70.86	321.52	65.06	327.32	64.10	328.28	61.96	330.42	60.19	332.19
L19	Saprolite	361	363.79	37.90	325.89	37.86	325.93	37.24	326.55	36.11	327.68	34.95	328.84	31.54	332.25	29.89	333.90
L20	Saprolite	363	365.52	40.71	324.81	40.78	324.74	40.20	325.32	39.26	326.26	38.57	326.95	35.86	329.66	35.35	330.17
L21	Saprolite	338	341.37	20.38	320.99	20.56	320.81	19.71	321.66	18.28	323.09	17.46	323.91	13.20	328.17	13.70	327.67
L21D	Saprolite/Interface	335	338.17	17.34	320.83	17.33	320.84	16.62	321.55	15.10	323.07	14.35	323.82	10.33	327.84	10.67	327.50
L22P1	Bedrock	414	416.62	81.13	335.49	80.36	336.26	80.25	336.37	79.93	336.69	78.89	337.73	77.99	338.63	77.53	339.09
L22P2	Bedrock	414	416.62	99.19	317.43	97.79	318.83	95.40	321.22	94.70	321.92	93.29	323.33	91.75	324.87	90.71	325.91
L23	Interface	379	382.29	57.56	324.73	57.62	324.67	57.20	325.09	56.54	325.75	55.63	326.66	53.36	328.93	51.92	330.37
L23D	Bedrock	379	381.94	57.22	324.72	57.30	324.64	56.88	325.06	56.24	325.70	55.31	326.63	53.06	328.88	51.62	330.32
L24	Saprolite	346	348.93	37.30	311.63	37.41	311.52	36.80	312.13	36.84	312.09	34.02	314.91	30.61	318.32	28.39	320.54
L25	Saprolite	366	369.08	36.96	332.12	37.12	331.96	NM	NM	36.08	333.00	35.28	333.80	32.97	336.11	31.19	337.89
MW11A	Saprolite	415	417.84	81.82	336.02	82.88	334.96	NM	NM	81.53	336.31	80.80	337.04	79.34	338.50	77.53	340.31
MW12	Saprolite	406	409.35	74.45	334.90	74.54	334.81	NM	NM	73.85	335.50	73.46	335.89	71.58	337.77	69.67	339.68
MW13	Interface	500	502.67	109.61	393.06	109.28	393.39	NM	NM	109.62	393.05	109.69	392.98	109.26	393.41	109.13	393.54
MW17	Saprolite	394	396.97	61.08	335.89	61.23	335.74	NM	NM	60.78	336.19	59.88	337.09	58.50	338.47	56.61	340.36
MW19	Interface	436	439.20	100.15	339.05	100.30	338.90	NM	NM	100.41	338.79	100.1	339.10	99.42	339.78	98.60	340.60
MW30	Saprolite/Interface	365	367.83	33.55	334.28	33.46	334.37	NM	NM	33.29	334.54	30.24	337.59	28.68	339.15	26.25	341.58
MW33	Saprolite/Interface	423	425.88	87.70	338.18	87.84	338.04	NM	NM	88.00	337.88	87.54	338.34	86.70	339.18	85.44	340.44
MW35	Saprolite	391	394.31	58.38	335.93	58.38	335.93	NM	NM	57.95	336.36	57.08	337.23	55.72	338.59	53.82	340.49

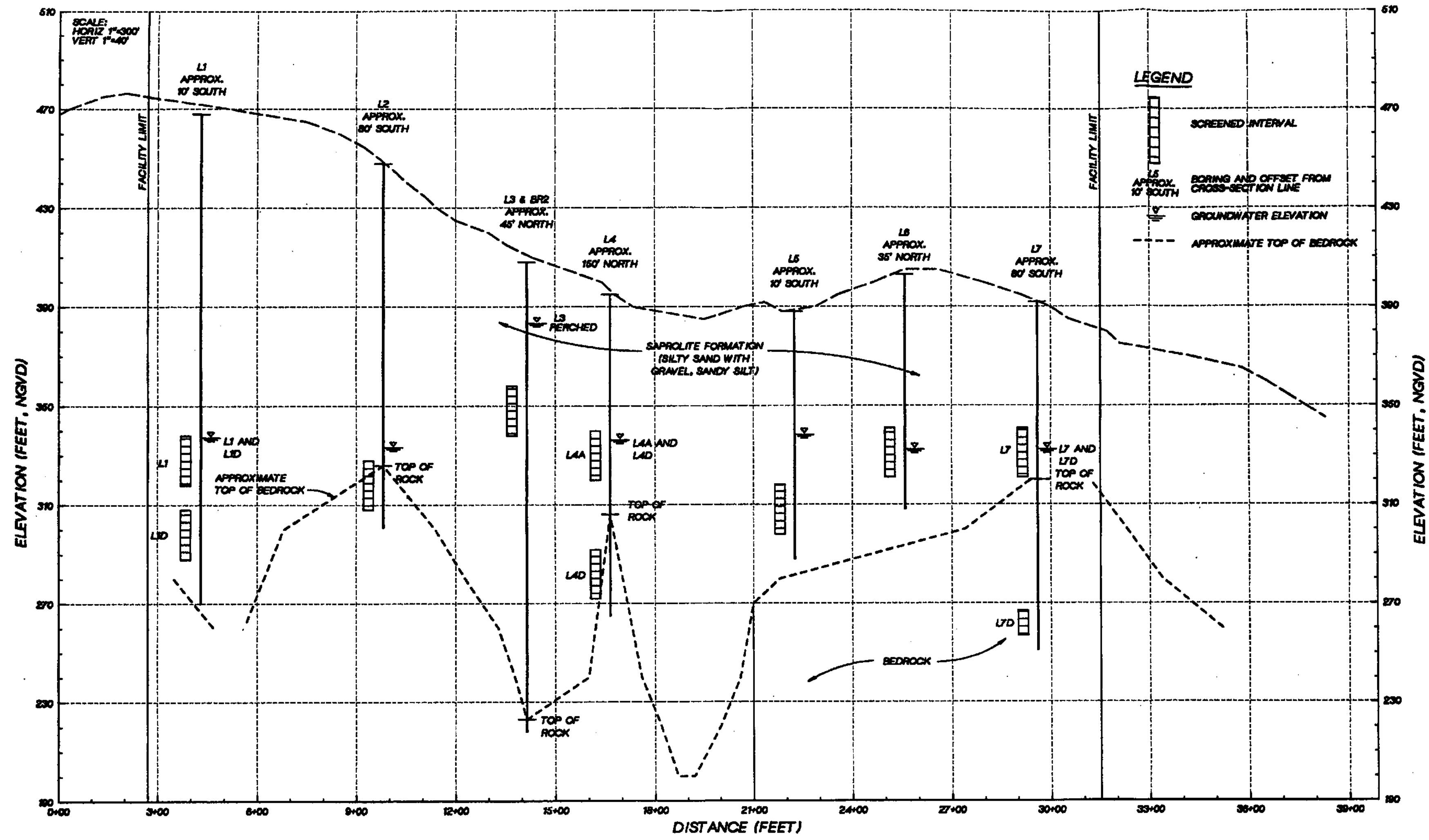
[a]Surveyed elevations of the top of the PVC well casings were provided by PSA, Inc.
NM = Not measured.



NOTES:

1. SEE FIGURE 8-2 FOR GEOLOGICAL CROSS-SECTION LOCATION.
2. WATER LEVEL RECORDINGS: 12/28/92
3. TOP OF ROCK ELEVATIONS IN BOREHOLES WHERE BEDROCK WAS NOT ENCOUNTERED WERE TAKEN FROM BEDROCK CONTOUR MAP, FIGURE 8-11.

Figure 8-4
GEOLOGIC CROSS SECTION A-A
Woods Road Solid Waste Management Facility



NOTES:

1. SEE FIGURE 8-2 FOR GEOLOGICAL CROSS -SECTION LOCATION.
2. WATER LEVEL RECORDINGS: 12/28/92
3. TOP OF ROCK ELEVATIONS IN BOREHOLES WHERE BEDROCK WAS NOT ENCOUNTERED WERE TAKEN FROM BEDROCK CONTOUR MAP, FIGURE 8-11.

Figure 8-10
GEOLOGIC CROSS SECTION G-G
Woods Road Solid Waste Management Facility

The risk of seismic activity causing surface displacement of the fault in the vicinity of the Woods Road facility is very low and does not pose a hazard.

A seismic risk map has been developed for the United States on the basis of the estimated probability of maximum ground acceleration in rock that can be expected for earthquakes occurring in a given seismic zone (Algermissen *et al.*). On the basis of this map, the maximum horizontal acceleration of bedrock expected in the vicinity of the Woods Road site from an earthquake with a 50-year return period is 0.10g (g equals gravitational acceleration). The proposed landfill facility will be designed to withstand this estimated acceleration.

8.4 Hydrologic and Hydrogeologic Conditions

8.4.1 Surface Water

This subsection describes features of surface water drainage at the facility and in the surrounding area. Hydrologic characteristics of the surface water flow system were evaluated on the basis of topographic contour maps produced by the United States Geological Survey (USGS). Flow of surface water onto and off the site is shown in Figure 8-12.

The surface water drainage system for the site was characterized by:

- Analyzing overland stormwater runoff onto and off the site
- Describing variations in infiltration rates on the basis of present and future land covers
- Identifying major drainage channels conveying water from the site

The site lies south of a relatively major topographic divide. Consequently, all surface water generally flows southward toward Goose Creek. With the exception of springs in the southern portion and outside the site boundary (see Figure 5-2), the surface drainages contain free water only for a few days after heavy rain.

8.4.2 Groundwater

Information obtained during drilling and from monitoring wells indicates that the local groundwater system consists of three water-bearing units within the uppermost aquifer beneath the site. These water-bearing units are hydraulically connected; that is, there are no confining layers that separate the units. The three water-bearing units within the uppermost aquifer are the saprolite unit, the interface unit, and the bedrock unit. The saprolite unit and the interface unit correspond to the saprolite site geology as shown in Figure 8-13. Based on the water-level data, ground surface elevations, and the top of bedrock, at the site, the typical depth to the water table from the ground surface is 50 feet and the average thickness of the saprolite and interface units is approximately 50 feet. Table 8-3 summarizes the thickness of the saprolite unit at the site.

The interface unit, where it exists, is typically the basal, highly permeable portion of the saprolite geology. The thickness of the interface unit averages approximately 4 feet. Table 8-3 summarizes the thickness of the interface unit in boreholes at the facility.

The bedrock unit underlies the saprolite and interface units. The bedrock unit is defined as the permeable portion of the bedrock site geology. The following discussion is a determination of an estimate for the thickness of the bedrock unit.

Four-hundred-ninety-two domestic water wells installed within the same geologic formation at other locations in Loudoun County, clearly shows that there is an abrupt 45 percent decrease in well yields that occurs at an average depth of 175 feet below the ground surface. These data are presented in Figure 8-14. Well yields generally continue to decrease with increasing depth except for those random wells that intersect a fracture or joint that is directly connected to the zone of high conductivity at the top of competent bedrock. Based on this data, it appears that lateral flow of groundwater more than 175 feet below grade is constrained due to the lack of continuous fractures in the bedrock.

A similar trend of yields occurs in the existing domestic water wells located on the site. The County has obtained data from 11 domestic wells, drilled to a maximum depth of 325 feet, for which drillers well completion reports are on file with the County Health Department. These data show that the average well yield for wells installed to a depth of 175 feet is about 24 gpm. Wells installed between 175 and 325 feet in depth show a 58 percent drop in yield to only 10.2 gpm (see Figure 8-14). Random higher yields are reported for a couple of wells drilled deeper than 325 feet. These are also attributed to intersecting a local fracture connected to the bedrock surface.

Since the average thickness of saprolite at the site is just over 100 feet, the data on domestic well yields indicate that the average thickness of the bedrock unit probably does not extend more than approximately 70 feet (175 feet - 103 feet) below the surface of competent bedrock.

Figure 8-13 depicts a generalized stratigraphic cross section and approximate average thicknesses of the three water-bearing units within the aquifer. Included in Figure 8-13 is the typical well yield observed during drilling operations.

The data that are discussed in the rest of this subsection indicate that the water table is primarily within the saprolite unit at the facility, and that the water-table aquifer is unconfined. Horizontal groundwater flow in the aquifer is primarily northwest to southeast, although flow to the southwest and east occurs below some portions of the facility. The average rate of groundwater flow in the water-table aquifer is estimated between 3 and 20 feet per year.

The underlying variability of the top of the bedrock has little effect on the overall groundwater flow pattern within the aquifer at the facility. The definition of the groundwater flow system within the water-table aquifer will allow a groundwater monitoring system to be implemented that will effectively monitor the aquifer, as required by Part 5.1.D of the SWMRs.

8.4.2.1 Groundwater-Level Data

The water level was measured in each of the monitoring wells and piezometers on four occasions (September 23, November 4, December 9, and December 28, 1992). The water-level data are presented in Table 8-4. Groundwater was encountered in monitoring wells across the site at depths ranging from approximately 15 to 130 feet below the ground surface. Groundwater elevations ranged from approximately 393 to 312 feet NGVD.

A potentiometric surface contour map of the water-table aquifer was developed for each of the four rounds of measurements on the basis of water-level data collected (Figure 8-15 through 8-18). Water-table contour maps for all rounds of water-level data reflect slight differences in water levels, but the overall configuration of the potentiometric surface and flow directions are very similar from one measurement round to the next. At all locations except L15 and L22, the water table is located within the saprolite or interface unit. At L15 and L22, where a bedrock ridge has been identified, the water table is within the bedrock.

Water-level data from monitoring wells L3 and L9 were excluded from the potentiometric contour maps. Anomalously high water levels in these wells indicated that these wells are screened in an isolated zone of perched water that is not hydraulically connected to the uppermost aquifer beneath the site. Water levels from BR4 and DW20, which are adjacent to L9, are approximately 44 feet below the level measured in L9. These data support the conclusion that L9 measured perched water. Because a perched zone was encountered definitively at only two adjacent locations during the monitoring well drilling program, the perched zone is not widespread beneath the facility.

Water levels measured during the 4 months of monitoring showed fluctuations ranging from 0.1 feet (L15 P2) to 5.6 feet (L13). This range of fluctuation is comparable to that observed in monitoring wells along the north side of the site that were installed for monitoring the adjacent existing sanitary landfill. Groundwater fluctuations for each of

APPENDIX A

APPENDIX A. THE SEISMIC REFRACTION METHOD

Introduction.

The seismic refraction survey is used to infer subsurface conditions on the basis of contrasting seismic wave velocities. The primary goal of the seismic survey is to rapidly and efficiently obtain subsurface information, thereby reducing direct investment costs, such as drilling. Geologic information typically obtained from a well-planned and executed seismic refraction survey will include: depth and shape of bedrock surface, nature and competency of bedrock (degree of fracturing and alteration), nature of overburden, and depth to water table. Modern portable equipment makes the method accessible to remote and rough regions. A review of seismic refraction theory, field methods, and interpretational procedures can be found in Dobrin (1976) and Telford et al (1990).

Instrumentation

The instrumentation involved in a seismic refraction survey consists of an energy source to generate seismic waves (typically explosives), a line of geophones to detect the seismic energy, and a seismograph which is essentially a highly accurate stopwatch. By measuring the arrival times of seismic waves at various distances from the energy source, or shotpoint, depths to interfaces and seismic velocities can be determined. Seismographs are usually 12- or 24-channel, in that they can simultaneously record the vibrations at 12 or 24 geophones. The record of these vibrations is a seismogram. Digital seismographs (e.g. ABEM Terraloc) acquire data with a built-in computer, whereas analog seismographs (e.g. ABEM Trio) output the data to photographic paper as it is acquired. The energy source must be coupled to the seismograph so that the instant of detonation or impact can be recorded. Timing marks, at 1 or 2 millisecond intervals, are provided to permit very accurate estimates of arrival times.

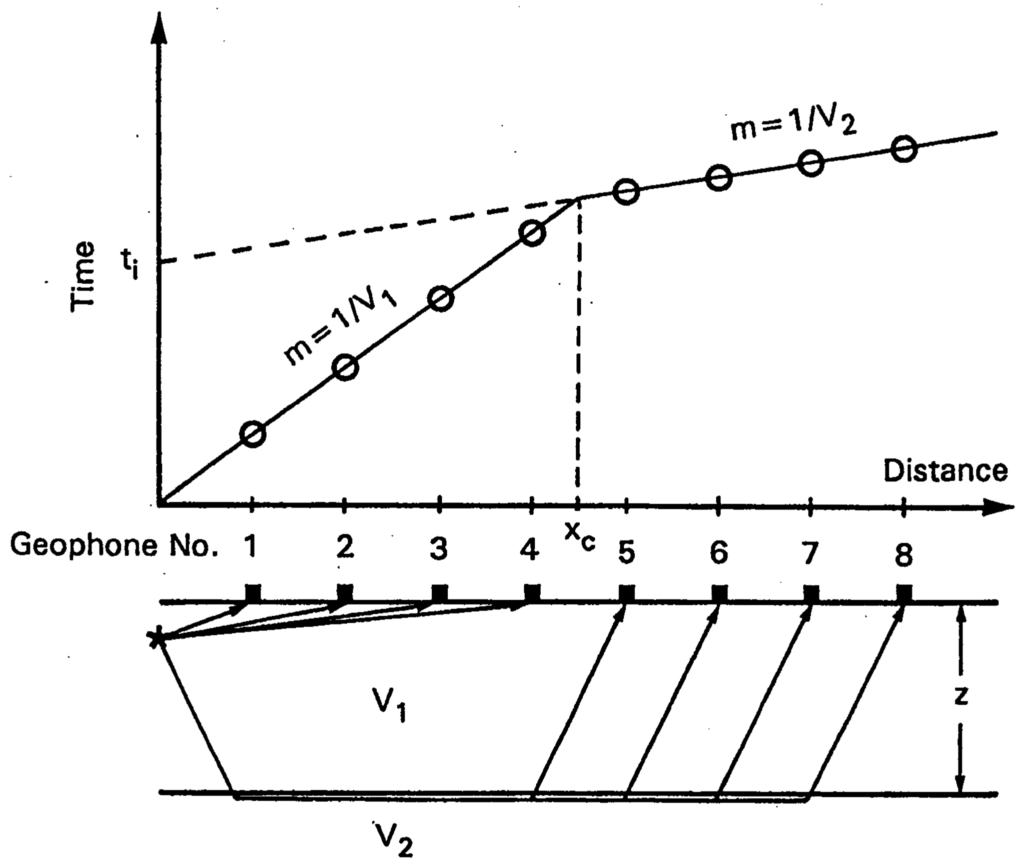
Fundamental Principles

The seismic refraction method relies on measuring the transit time of the wave that takes the shortest time to travel from the shotpoint to each geophone. The fastest seismic waves are the compressional (P) or acoustic waves, where displaced particles oscillate in the direction of wave propagation. The energy that follows this "first arrival", such as reflected waves or transverse (S) waves, is not considered under routine seismic refraction interpretation.

Figure A shows a simple geologic structure, where a layer with a velocity of V_1 overlies a second layer with a higher velocity, V_2. At one end of the spread, a shotpoint is detonated and the vibrations at each geophone are recorded. Seismic waves will travel via the direct path from the source to each of the geophones. Waves may also be refracted at some critical angle along the interface and travel at the higher velocity of V_2. Energy is continually leaked back to the surface as it travels along the interface. A time-distance graph may be constructed, plotting the first arrival transit times as a function of position along the seismic line. The first arrival at the closest geophones is the direct wave. However, at the critical or crossover distance, x_c, the refracted wave which travels along the higher velocity layer overtakes the direct arrival. The inverse slope of a straight line segment of the time-distance curve is equal to the velocity in that layer. The crossover distance is directly proportional to the depth of the interface.

Interpretation

The simplest methods of interpretation are illustrated in Figure A. Having determined the velocity of compressional waves through each layer, one may calculate the depths according to crossover distance or the intercept time formulas. The case of a horizontal interface, illustrated in Figure A, becomes slightly more complicated if the planar interface is dipping. The general case of an irregular interface can be handled by more complex interpretational schemes, including various delay-time methods, the reciprocal



V_1 = Velocity of Upper Layer
V_2 = Velocity of Lower Layer
m = Slope of Line Segment
x_c = Crossover Distance
t_i = Intercept Time

$$z=\frac{x_c}{2}\sqrt{\frac{V_2-V_1}{V_2+V_1}} \qquad z=\frac{t_i}{2}\frac{V_2V_1}{\sqrt{V_2^2-V_1^2}}$$

Figure A. Principles of Seismic Refraction and generalized reciprocal methods, and ray tracing. One method may be better suited than another to a particular geologic environment. Although computer programs are now routinely used to implement these methods, the constant interaction and judgment of the geophysicist and geologist are still required.

Limitations

Two important limitations of the seismic refraction method must be kept in mind. First, layers of insufficient thickness and velocity contrast will not produce first arrivals at the surface. This is the "hidden layer" problem. For example, a thin layer of glacial till or weathered bedrock overlying unweathered bedrock might be such a hidden layer. The presence of a hidden layer will lead to calculated depths that are too shallow. Secondly, the seismic refraction method requires that the velocities of all layers increase with depth. A low velocity layer at depth is termed a "blind zone." Such layers will not yield first arrivals because critical refractions cannot occur. Computed depths will be greater than actual depths in this case. Fortunately, such velocity reversals are seldom encountered in shallow surveys. The generalized reciprocal method can be used to infer the absence or presence of blind zones and hidden layers. However, correlation with boreholes and uphole surveys may be necessary to accurately gauge the effects of such layers.

The seismic reflection method relies on measuring the time for energy to travel from the source to a subsurface reflector, and back to the surface. Reflections will always arrive after the direct or critically-refracted wave. An interface which exhibits a contrast in acoustic impedance (the product of velocity and density) will produce a reflection. Therefore, the seismic reflection method is able to detect layers that are hidden or blind to the seismic refraction method. Reflections will even occur at an interface separating materials of identical velocity, provided that their densities differ. Furthermore, seismic reflection can be used to gain information at great depths. In many ways, seismic reflection and refraction are complementary methods.

References

Dobrin, M.B., 1976, Introduction of Geophysical Prospecting, 3rd ed.: New York, McGraw-Hill Book Co., Inc.

Telford, W.M., Geldard, L.P., and Sheriff, R.E., 1990, Applied Geophysics, 2nd ed.: New York, Cambridge University Press.

Sharon

Engineers
Planners
Economists
Scientists

CH2M HILL

July 12, 1993

WDC35168.A2.60

Mr. Richard Essex
Geologist Senior
Department of Environmental Quality
Office of Permits
James Monroe Building, Eleventh Floor
101 North Fourteenth Street
Richmond, Virginia 23219

Dear Mr. Essex:

Subject: The Woods Road Solid Waste Management Facility Part A Permit Application

The purpose of this letter is to clarify our response to the Waste Division of the Department of Environmental Quality comments, dated July 9, 1993, regarding the Woods Road Solid Waste Management Facility Part A permit application supplemental information submitted on May 27, 1993. As indicated in your letter, dated July 9, 1993, the Woods Road site is located in a seismic impact zone and therefore, the following demonstrations are required per Section 5.1.A.6 of the *Virginia Solid Waste Management Regulations* (VR 672-20-10) and include:

- Determine expected peak horizontal ground acceleration from the maximum earthquake.
- Determine site specific seismic hazards.
- Demonstrate that the design of the proposed facilities mitigates the effects of peak ground accelerations.

The following paragraphs provide responses to each of these requirements.

As a clarification to Comment response No. 3 of our letter dated May 27, 1993, the maximum expected horizontal acceleration in bedrock with a 10 percent chance of occurring in a 250 year return period is 0.1g. The depth to top of rock from the ground surface at the Woods Road site varies from 51 to 103 feet with an average depth of 103 feet. The soils overlying bedrock generally consist of medium dense well graded silty sand to firm sandy silt. The maximum anticipated amplification factor for these site conditions is 1.5. The maximum expected

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horizontal acceleration in the soils, overlying bedrock, with a 10 percent chance of occurring in a 250 year return period is 0.15g (see attached calculations).

The factor of safety against liquefaction at the Woods Road site, for a magnitude 5 earthquake, is 3.9. The factors that contribute include the depth to groundwater (50 foot average), high confining pressures at depths greater than 50 feet (greater than 9,200 psf), silt and clay contents averaging 45 percent by weight, and the saprolites retention of the parent rock structure. All these factors mitigate the potential for liquefaction at the site (see attached calculations).

All containment structures at the proposed Woods Road site will be designed to mitigate the effects of peak ground accelerations that could effect the stability of these structures. Calculations and supporting documentation will be included in the Part B permit application.

Please do not hesitate to call me if you have any questions.

Sincerely,

CH2M HILL

Martin A. Reif, P.E.
Task Manager

parta/cr071293
enclosures (5)
cc Sharon Hodges (2)
Rick Weber (1)

A. DETERMINE WHETHER THE WOODS ROAD SITE IS LOCATED IN A SEISMIC IMPACT ZONE (SIZ).

THE PROPOSED WOODS ROAD SITE IS LOCATED IN A SIZ WITH A MAXIMUM HORIZONTAL ACCELERATION IN BEDROCK OF 0.1 g (SEE ATTACHED FIGURE MODIFIED FROM ALGERMISSEN ET AL 1990).

B. DETERMINE THE SOIL AMPLIFICATION FACTOR:

THE DEPTH TO BEDROCK VARIES FROM 51 TO 203 FEET BELOW THE GROUND SURFACE WITH AN AVERAGE DEPTH OF 103 FEET.

GROUND WATER VARIES FROM 15 TO 130 FEET BELOW THE GROUND SURFACE WITH AN AVERAGE DEPTH OF 56 FT

THE MATERIAL OVERLYING BEDROCK GENERALLY CONSISTS OF A RESIDUAL SOIL WITH AN AVERAGE COMPOSITION OF 30% SILT (4-54); 27% F-M SAND (10-54); 15% GRAVEL (0-76); 15% CLAY (2-38); AND 13% C. SAND (0-48).

THE MATERIAL CAN GENERALLY BE CLASSIFIED AS A MEDIUM DENSE WELL GRADED SILTY SAND (SM) TO FIRM SANDY SILT (ML)

SOIL AMPLIFICATION FACTOR FOR THIS TYPE OF MATERIAL IS CONSERVATIVELY 1.5 (SEE ATTACHED TABLE 2 AND TABLE 6)

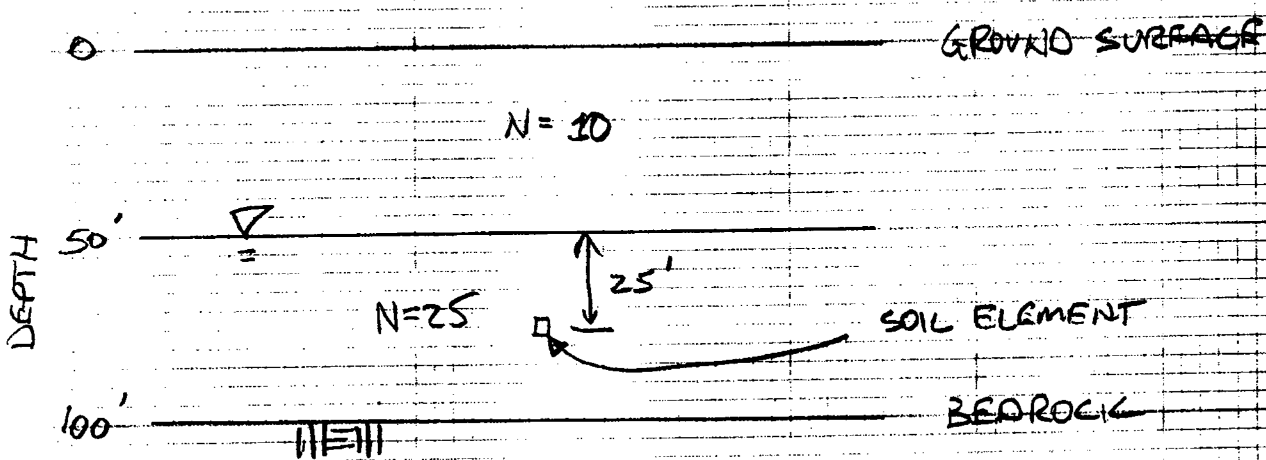
C. DETERMINE LIQUIFACTION POTENTIAL AT THE WOODS ROAD SITE

$$\tau/\sigma = \frac{0.65\, a\, \sigma_o\, r_d}{\sigma_o\, g}$$ (SEED ET AL 1983)

WHERE: τ/σ = CYCLIC STRESS RATIO
τ = AVERAGE PEAK SHEAR STRESS
σ_o = INITIAL VERTICAL EFFECTIVE STRESS
a = MAX ACCELERATION @ GROUND SURFACE
σ = TOTAL OVERBURDEN STRESS
r_d = STRESS REDUCTION FACTOR = 0.75 (SEE FIG ATTACHED)
g = ACCELERATION DUE TO GRAVITY

USE SIMPLIFIED PROCEDURE FOR EVALUATING STRESSES INDUCED BY EARTH QUAKES (SEED & IDRISS, 1982, PG 74)

GENERALIZED SITE PROFILE



$$\tau/\sigma = \frac{0.65\,(32.2\ FT^2/SEC)(115\ LB/FT^3 \times 75\ FT)\ (0.75)(0.15)}{(115\ LB/FT^3 \times 50\ FT + 115-62.4 \times 25)\ (32.2\ FT^2/SEC)}$$

$$\tau/\sigma = \frac{20,309\ LB/SEC}{227,493\ LB/SEC} = 0.089$$

DETERMINE N_1

$N_1 = C_N \; N$

$C_N = 0.5$ (SEE ATTACHED FIGURE 47, SEED ET AL 1982)

$N_1 = 0.5\,(25) = 12.5$

FOR SILTSANDS SUCH AS AT THE WOODS ROAD SITE N_1 SHOULD BE INCREASED BY 7.5

$\therefore N_1 = 20$

ENTER FIGURE 57 (SEED ET AL 1982)
WITH $N_1 = 20$
$\tau/\sigma = 0.089$

THE LIQUIFACTION POTENTIAL IS VERY LOW REQUIRING > $m = 8\tfrac{1}{2}$ EARTHQUAKE

IN ADDITION LIQUIFACTION GENERALLY OCCURS AT SHALLOW DEPTHS WITH SHALLOW GROUNDWATER

GROUNDWATER DEPTHS AT THE WOODS ROAD SITE AVERAGE 50 FEET BELOW THE GROUND SURFACE AND THE RELICK ROCK STRUCTURE AND CONFINING PRESSURES SIGNIFICANTLY LIMIT LIQUIFACTION POTENTIAL

ASSUMING MAGNITUDE 5 EARTHQUAKE IS THE THRESHOLD FOR LIQUEFACTION THEN FROM FIGURE 57 WITH $N_1 = 20$ AND $m = 5$

CH2M HILL SUBJECT WOODS ROAD SWMF BY M REIF DATE 7/12/93
PROJECT NO. SHT 4 OF 9

$\tau/\sigma = 0.35$ MAX CYCLIC SHEAR STRESS FOR $M=5$ $N_1=20$

$$FS = \frac{0.35}{0.09} = 3.9$$

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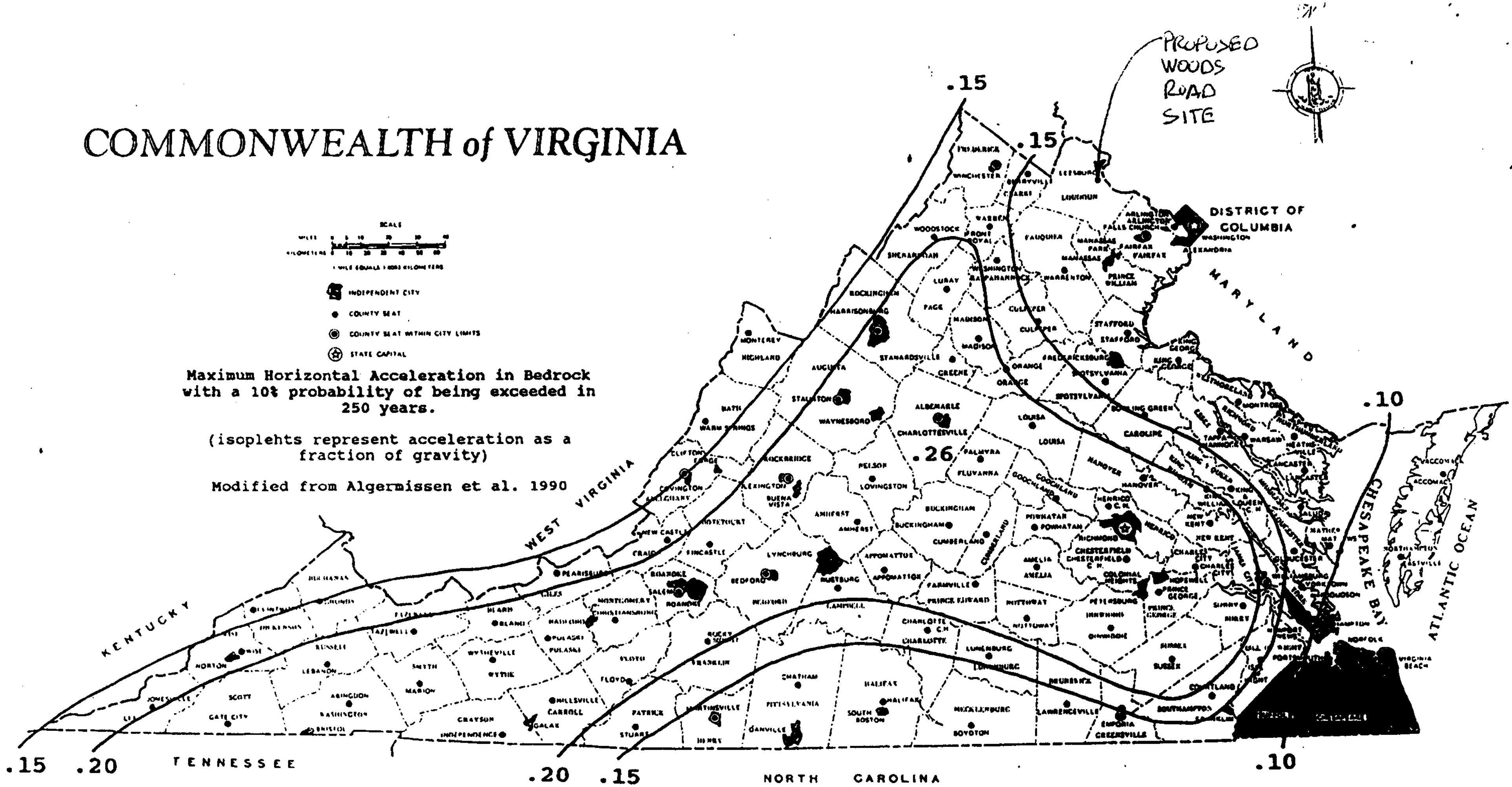
INYANG, H.I., 1991 HAZARDOUS WASTE FACILITIES IN SEISMIC ZONE., DEPT OF CIVIL ENGINEERING UNIVERSITY OF WISCONSIN - PLATTEVILLE, PLATTEVILE, WI 53818

SEED H.B., AND IDRISS I.M., 1982, GROUND MOTIONS AND SOIL LIQUEFACTION DURING EARTHQUAKES, MONOGRAPH SERIES, EARTHQUAKE ENGINEERING RESEARCH CENTER, BERKELEY, CA 94720.



The Virginia Solid Waste Management Regulations (VR 672-20-10) place restrictions on the establishment of new landfills or lateral expansion of existing units in Seismic Impact Zones. A "seismic impact zone" (as defined in §1.0 of the VSWMR) is "an area with a ten percent or greater probability that the maximum horizontal acceleration in lithified earth material, expressed as a percentage of the earth's gravitational pull (g), will exceed 0.10g in 250 years".

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Table 2. Design Amplification Factors for Soil on Rock Seismic Accelerations to be Used in Landfill Design in Seismic Areas

Situation Category	Amplification Factor	Soil Type	Soil Depth
(i)	1.0	Rock Dense to very dense coarse-grained soils, and very stiff to hard fine-grained soils	All depths
		Compact coarse-grained soils, and firm to stiff fine-grained soils	0-50 ft.
(ii)	1.5	Compact coarse-grained soils, and firm to stiff fine-grained soils	>50 ft. ← WOODS ROAD SITE
		Very loose and loose coarse-grained soils, and very soft to soft fine-grained soils	0-50 ft.
(iii)	2.0	Very loose and loose coarse-grained soils, and very soft to soft fine-grained soils	>50 ft.

(H. INYANG, 1992)

Factor F	Soil Type	Soil Depth
1.0	Rock Dense to very dense coarse-grained soils Very stiff to hard fine grained soils	All Depths
	Compact coarse-grained soils Firm to stiff fine-grained soils	0 to 50 ft
1.3	Compact coarse-grained soils Firm to stiff fine-grained soils	>50 ft ← WOODS ROAD SITE
	Very loose and loose coarse-grained soils Very soft to soft fine-grained soils	0 to 50 ft
1.5	Very loose and loose coarse-grained soils Very soft to soft fine-grained soils	>50 ft

Table 6. Factors for soil amplification of bedrock seismic acceleration (CGS 1978)

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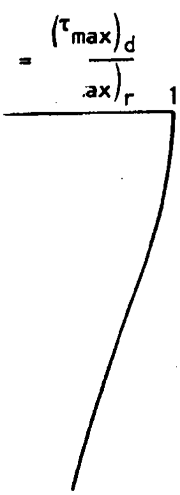

(c)

ress, $(\tau_{max})_r$.

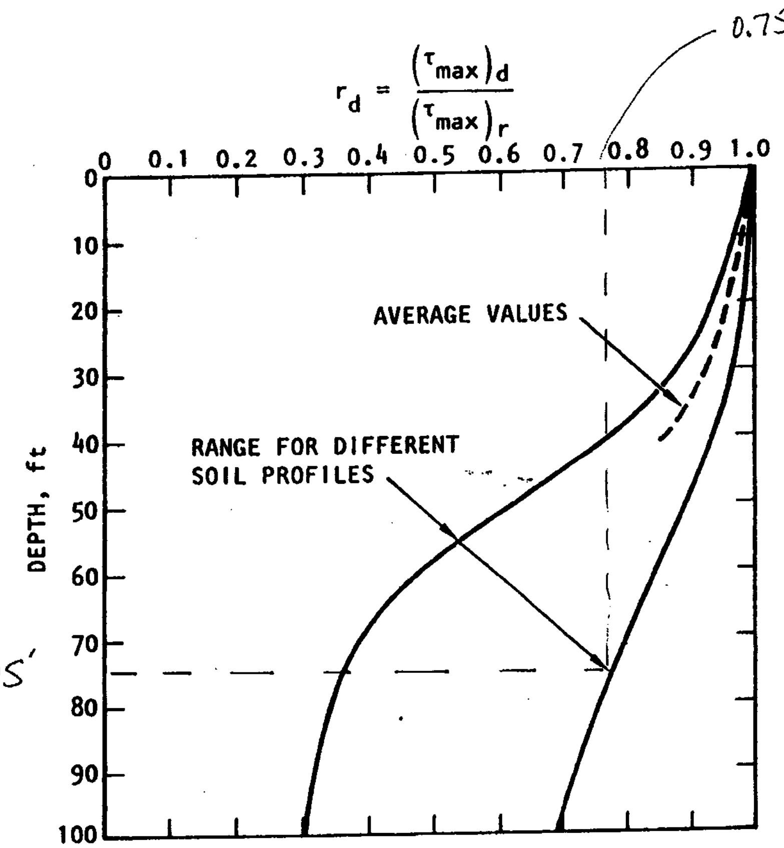

Figure 40. Range of values of r_d for different soil profiles.

where r_d is a stress reduction coefficient with a value less than 1. The variations of $(\tau_{max})_r$ and $(\tau_{max})_d$ will typically have the form shown in Fig. 39(b) and, in any given deposit, the value of r_d will decrease from a value of 1 at the ground surface to much lower values at large depths, as shown in Fig. 39(c).

Computations of the value of r_d for a wide variety of earthquake motions and soil conditions having sand in the upper 50 ft. have shown that r_d generally falls within the range of values shown in Fig. 40. It may be seen that in the upper 30 or 40 ft., the scatter of the results is not great and, for any of the deposits, the error involved in using the average values shown by the dashed line would generally be less than about 5%. Thus

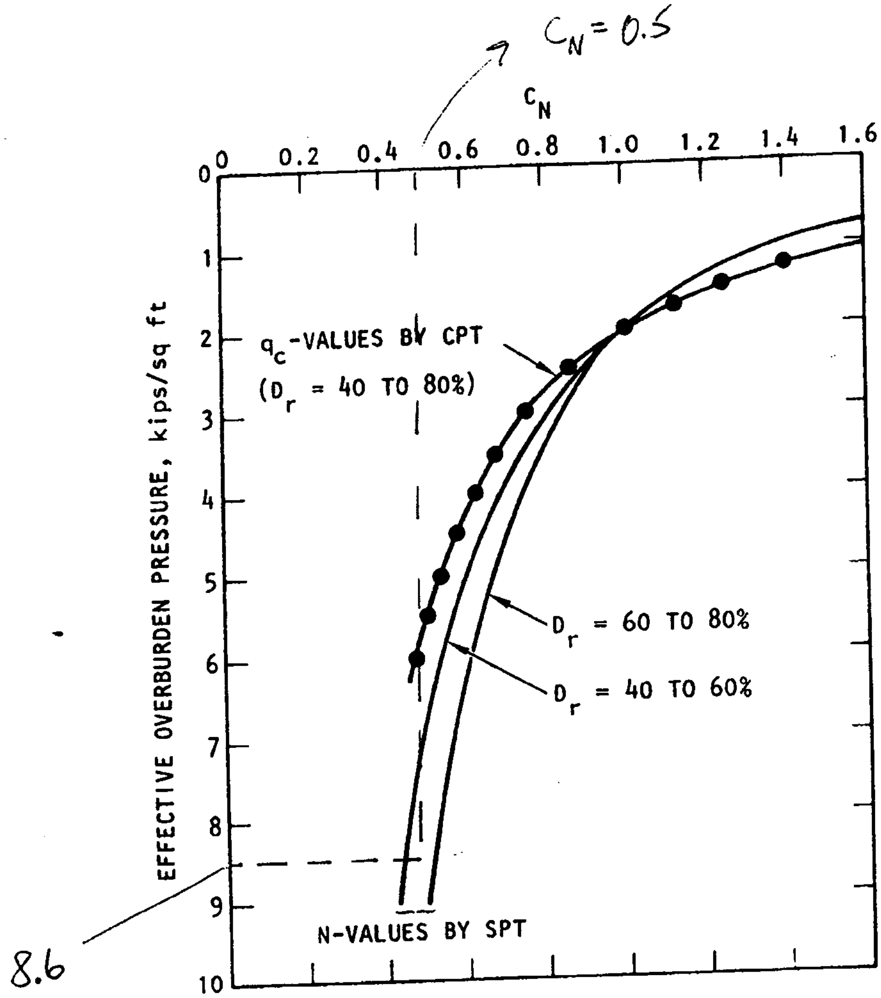

Figure 47. Chart for values of C_N.

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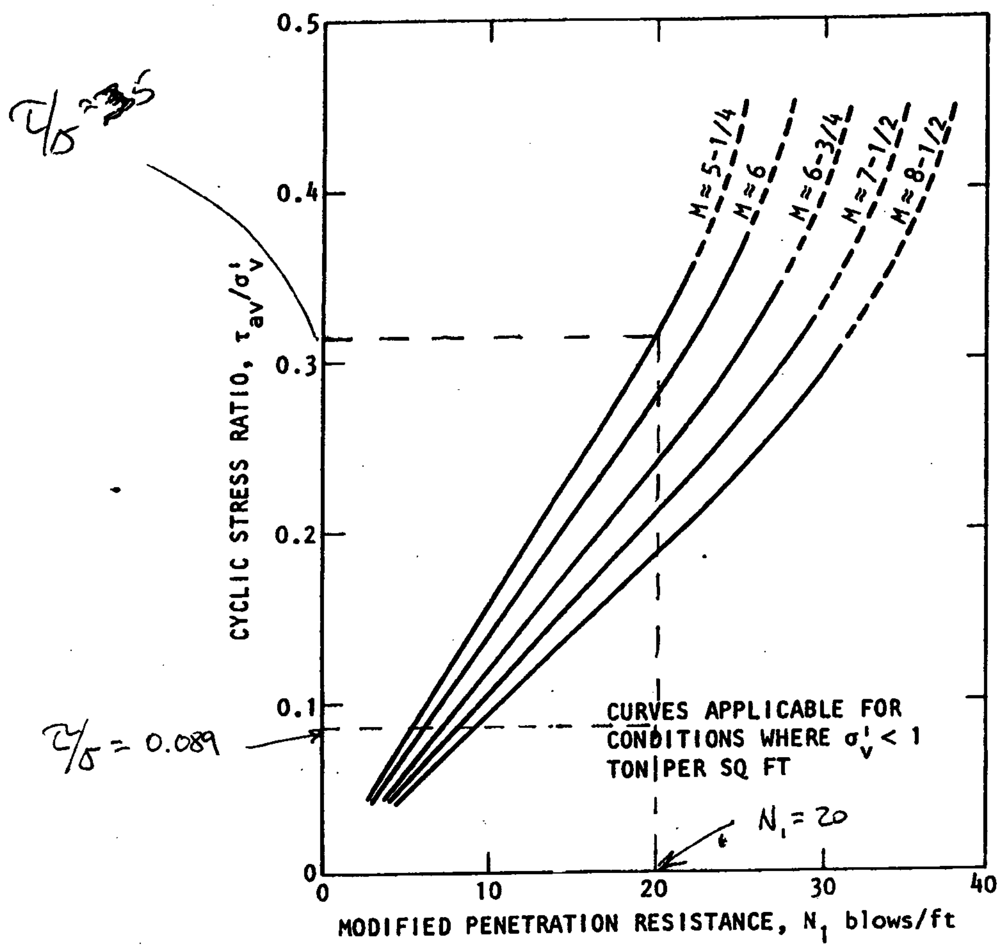

Figure 57. Chart for evaluation of liquefaction potential for sands for different magnitude earthquakes.